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REPORT

TO THE

TOWN COUNCIL

UPON

A WATER SUPPLY

FOR

LEBANON, PENN'A.,

BY

HENRY P. M. BIRKINBINE, Engineer.

Presented March 29, 1870.

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REPORT

To the Burgesses and Town Council of the Borough of Lebanon, Pennsylvania :—

Gentlemen :—

Agreeably to your resolution of December 15th, 1869, directing me to report upon the best, available means of supplying your Borough with water ; I commenced the examinations and surveys on December 21st, from which I am now able to present the following :—

REPORT AND APPROXIMATE ESTIMATES.

In the earlier history of Lebanon the Quittapahilla creek furnished an abundant supply of good potable water, and the location of the town was probably made with a view of enjoying its benefits. The clearing and cultivation of the land, the washings from roads and streets and other objectionable matter flowing into the stream ; and the construction of dams where quantities of mud accumulate have impaired its quality. But with all these disadvantages the water, if taken from the creek above the paper-mill drainage, is, with but few exceptions the best for domestic purposes now in use in the Borough. There are undoubtedly some springs or wells within the borough limits where good water is still procurable, but by careful examination most of them will be found to be more or less contaminated by infiltration from sinks, sewage and other objectionable sources.

The waters of wells which are particularly esteemed have upon examination been found to contain very deleterious matter, not discernable to sight, taste, or smell, yet to the use of which has been traced much sickness, particularly when the system is most liable to be affected, as in the case of contagious diseases.

When the cholera visited London in 1853-4 in the districts supplied with impure water there were 130 deaths in 10,000, and but 37 deaths in 10,000 in the districts supplied with better water.

C. F. Chandler, Ph. D. Chemist to the New York Metropolitan Board of Health in speaking of the Croton water supply says, "No single improvement can contribute more toward the prevention of cholera and simllar diseases. Let every well be filled up, that the people "may be no longer compelled, by ignorance or necessity, to drink the "soakage of the soil, which is always polluted in the neighborhood of "human habitations."

The sanitary statistics of England, which are very carefully kept, show a marked improvement in the general health and a decrease of the mortality rate in every instance where a copious supply of good water has been introduced into a town, and where coupled with this there has been a thorough system of underground drainage, these effects are most noticeable. An idea of the value of these improvements may be obtained from the three cases appended.

Cardiff, with a population of 43,000, had an average death-rate of 33.2 in 1000, which was reduced to 22 in 1000 by the introduction of water and sewage improvements, and the decrease of typhus fever cases has been 40 per cent. and of phthysis cases 17 per cent.

In *Croydon*, a town of 30,000 inhabitants, by the same causes the death-rate was decreased from 23.7 in 1000 to 18.6 in 1000 ; and the reduction of typhoid fever cases was 63 per cent. and of phthysis cases was 17 per cent.

The death-rate of Salsbury, (a town with a population of 9,000) was in the same manner reduced from 27.5 in 1000 to 21.9 in 1000 ; and the decrease of typhoid fever cases is 75 per cent. and of consumption and kindred diseases 49 per cent.

The Croydon water supply cost $610,000, and the sewers, public baths, abbattoirs and other sanitary works $450,000, yet the engineer by carefully prepared estimates of the value of time saved by the improved health and longevity of the inhabitants, and of the cost of funeral expenses, has shown that the works were more than paid for in thirteen years, and that 60,975 cases of sickness were presented, and the lives of 2,439 persons saved in that time. Upon these considerations no money value can be placed.

Who would not be heavily taxed for these improvements by which six years is added to the average life of the inhabitants of the town, and many days of health and its consequent enjoyments ?

To insure the full benefits enumerated above, there should be not only an adequate supply of good wholesome water, but also a complete and efficient system of underground sewage and other sanitary precautions.

It would be advisable to take the subject of sewage into consideration at this time in connection with your water supply ; to have a system of underground drainage prepared and adopted, and construct all drains in conformity with this plan. By this means you will secure a thorough and complete system without the loss of any of the parts which may have been constructed in advance of others: for want of such provisions large sums of money have been wasted by cities and towns in changes and alterations.

Water is the most ready and efficient means of removing all manner of house drainage and offal in gutters and sewers, and conveying these promoters of disease beyond the town limits. It is also the means relied upon for the extinguishing of conflagrations, and no better safeguard is known than an abundant supply of water under pressure which can immediately be brought to bear upon the flames. The feeling of security thus given is in itself a valuable consideration and the reduction of the risk from fire will bring a corresponding decrease in the premiums demanded for insurance. The convenience of having an abundance of water procurable at all times in any part of a house, the many comforts thus added to our homes, and the labor saved in pumping and carrying are considerations of importance.

When the exchange of a limited amount of what, at best, must be considered water of doubtful potability, for an abundant supply of that which is pure and soft, no difference of opinion can exist even if the change is effected at a heavy pecuniary sacrifice.

QUANTITY OF WATER REQUIRED.

The amount of water required per day per inhabitant in cities supplied with water, varies considerably from 25 to 50 gallons or more.

The amount required has from year to year been constantly increasing in towns and cities already supplied, owing to the increased comforts and conveniences of modern residences and the new uses to which water is being put. In Boston water meters were attached to a number of dwellings for the purpose of ascertaining the amount of water used.—For 29 houses, (three with bath rooms,) the average was 296 gallons per day, allowing 7 persons to a house, the per capita amount required is 42.5 gallons.

In the estimates for a present supply for Lebanon 50 gallons per day has been assumed as sufficient for all purposes. Estimating the present population as 10.000 a daily supply of 500.000 gallons will be required. But arrangements should be made to meet the demands of the railroads, manufactories, and the

PROSPECTIVE GROWTH OF THE TOWN.

Perhaps no town in the country possesses greater advantages as a location for manufacturing establishments, particularly in the production and working of iron, than Lebanon. The water power of the Merrimac River at Lowell, Mass., which is equal to 10.000 Horse power, and which has Lake Winnipisiogec as a store reservoir to insure a constant supply in all seasons, is one of the finest in the country: and is applied in the best manner to the most durable and efficient motors; it is rented out to the manufactories at the rate of ten cents per horse power per day.

A steam engine of ordinary construction will consume per horse power about 50 pounds of Coal per day, or if engines of superior economy are used the consumption will be but about 30 pounds per day. Taking the value of Coal at Lebanon at $3.50 per ton, or 0.156 cents per pound, the cost of a horse power in Lebanon is from 4-7 to 7-8 cents per day.—Making due allowance for attendance and the wear of steam over water motors the difference is still in favor of Lebanon.

Steam is the most ready means for heating in winter, and is indispensible in many operations in manufacturing, dyeing, etc.; and in the twelve larger establishments in Lowell over 38,000 tons of Anthracite Coal was used last year in connection with the water power, (the freigh-and charges upon which would fully equal the cost of the Coal at Lebanon.) It is evident that the advantages possessed by your town in the cost of fuel alone would make in many instances an important dividend upon the investment of a manufacturing establishment.

Water as a power (except in a few locations peculialy circumstanced) connot now compete with steam, for "Fire is the material force, or Nerve power, and iron and steel the muscles of our modern civilization."

When the smelting of ore and the manufacture of iron is brought into comparison, there are few localities, if any, which are so favorably situated as Lebanon. The whole Lebanon Valley is one vast bed of good limestone, inexhaustible in quantity, to be used as a flux in reducing the iron ore which abounds either in the numerous pockets of *hematite* distributed throughout the neighborhood, or in that most wonderful phenomenon of Nature, the Cornwall Ore Banks. (This is an immense and probably inexhaustible supply of *magnetic* iron ore, the most extensive in the state, connected with the town by but six miles of railroad.)

The iron will be melted by the use of coal brought from the anthracite regions by the Pinegrove and Lebanon Rail Road. With coal within 25 miles, iron ore close to the town, and limestone everywhere, it is difficult to predict too bright a future for Lebanon in iron making and working, for the amount of iron made and worked is already very considerable,

Add to these advantages a healthy climate, and a soil unsurpassed for fertility, and Lebanon surely is well located.

It is therefore difficult to estimate what will be the prospective requirements of a water supply, and your instructions to provide a supply of three million gallons per day is probably within the bounds of what will be demanded within less than twenty years.

SOURCES OF SUPPLY.

To procure an ample supply of good wholesome water for Lebanon is a problem of some difficulty, when it is necessary to come within the means of the town and keep the construction of the requisite works from being burdensome to the tax-payers. The unusual difficulties in accomplishing this desired result have undoubtedly delayed the construction of the works for a long time. While a comparatively small and inexpensive works would meet the present demands of the town, the following estimates are for a works looking to the future, with a capacity as suggested by councils of 3.000.000 gallons per day.

Several projects have been presented to the consideration of the people and recommended by able engineers, residents of your town ; and from the character of these gentlemen and their standing in their profession the plans presented by them deserve and have received a most careful investigation. These projects are

First. Procuring a supply by gravitation from the head-waters of the Hammer Creek, recommended by L. R. Hynicka, C. E., Superintendent of the Union Canal Company.

Second. Taking the water from Schnitz Creek, about two miles from the town, and pumping it by steam into a reservior, recommended by W. Lorenz, C. E., Resident Engineer of the Philadelphia and Reading Rail Road.

All the sources which were believed to be available have been carefully examined, and over forty-two (42) miles of surveys run to determine the practicability of obtaining a supply from the following sources :

First. The Little Swatara Creek by pumping.

Second. Schnitz creek by pumping.

Third. South Mountain by gravitation.

Fourth. The Quittapahilla Creek by pumping.

Some attention has also been given to the store reservoir of the Union Canal Company known as Stœver's Dam ; the Brandywine Creek and the abandoned Canal feeder.

The accompanying map will exhibit the various sources examined.—The drainage areas of the streams are differently colored, and the lines of Conduit from them shown.

All roads and other unnecessary features of the country have been omitted so as more plainly to represent the hydography of the vicinity.

CAPACITY OF SOURCES.

While gauging will determine the actual amount of water flowing in a stream at the time of observation, a great number of measurements extending over many years will be necessary to ascertain the average capacity, particularly if the stream be a small one draining a contracted area immediately effected by rain or drought. A more reliable plan is to use the rain fall, (when it can be ascertained,) as a basis of calculation.

Through the kindness of Samuel B. Lehman, Esq., access has been had to valuable records of rain fall extending back over forty years, from which table "*A*" has been prepared, exhibiting the maximims, minimums, and means of precipitation for day, month, season and year.—These figures, though taken at Lebanon, will be sufficiently accurate for the entire area examined for a water supply, and will therefore so far as the quantity of water procurable from the various sources is concerned, form the basis of calculation.

The amount of water that can be secured from a given drainage area is variously estimated. Much depends upon the character, topography, and geology of the country and the capacity of the store reservoirs.

In practice the Union Canal Company estimate that in the vicinity of Lebanon one third of the rain fall can be utilized. This may be sufficiently accurate for canal purposes, but when the water supply of a town is under consideration, it becomes necessary to examine the subject more carefully.

Twelve cities in England which procure their water supplies from impounding reservoirs, utilize an average of .509 of the rain fall upon the drainage areas.

The water-shed drained into Lake Cochituate from which Boston is supplied is 11.400 acres, and from this by careful measurements made for fourteen years, it has been ascertained that a daily average of 21.716.-700 gallons flowed into the lake ; making the average available rain fall 46 per cent.

The amount lost by evaporation, vegetation, and such absorption as does not reappear in springs in the area drained for the supply of Brooklyn, is 15 inches in an average rain fall of 43 inches.

In the measurement of the sources of the Mississippi, General Humphries gives the amounts flowing in small streams among the hills as .8 to .9 of rain fall upon their drainage areas.

The yield of a number of springs in England in extreme drought was found by actual measurement to be from .25 to .75 of a cubic foot per second for each 1000 acres drained.

In the Croton drainage from which New York is supplied the minimum flow is found to be .3 of a cubic foot for 1000 acres, and in the ponds supplying Brooklyn .77 of a cubic foot per 1000 acres.

This would give a minimum yield per square mile per day, without surface water for .25 cubic feet per second, 103.680 gallons per day.
.30 do. do. 124.416 do. do.
.50 do. do. 207.360 do. do.
.77 do. do. 319.334 do. do.

Every summer, particularly in times of drought, numbers of showers occur, no part of which finds its way to springs and streams, but is entirely evaporated and absorbed by vegetation.

Table "A."

MEANS AND EXTREMES OF RAIN-FALL AT LEBANON, PA.

	MAXIMUMS.		MINIMUMS.		MEANS.	
	Inches.	Date.	Inch's.	Date.	Inch's.	Extent of Observa'n
January,	5.61	1850	1.09	1851	3.11	42 years.
February,	5.05	1854	0.56	1833	2.54	41 do.
March,	6.65	1865	0.59	1839	3.07	41 do.
April,	5.67	1851	0.57	1833	3.29	40 do.
May,	10.65	1860	1.17	1831	4.56	40 do.
June,	10.05	1857	0.49	1853	4.38	40 do.
July,	11.43	1863	0.39	1849	4.00	41 do.
August,	12.72	1867	0.80	1854	3.37	41 do,
September,	10.20	1859	0.71	1849	3.50	41 do,
October,	7.39	1869	1.14	1839	3.33	41 do,
November,	6.65	1852	1.31	1837	3.25	41 do.
December,	6.68	1847	0.22	1828	3.31	41 do,
Spring,	16.71	1857	5.82	1845	10.96	40Seas'ns
Summer,	22.05	1850	5.86	1849	11.79	40 do.
Autumn,	15.81	1859	5.99	1856	10.11	41 do.
Winter,	15.31	1849–50	6.01	1829–30 1857–58	8.94	40 do,
Year,	64.17	1850	30.86	1840	42.126	40 years.
Month,	12.72	Aug.'67	0.22	Dec.'28	3.494	490 mos
Day,	0.1758	1850	0,0843	1840	0.1148	14915 ds.

From the above statements and personal observations and measurements I believe a safe estimate of the available rain fall upon the country drained by the various streams examined, will be on an average:

Little Swatara Creek,	46 *per cent.*
Schnitz Creek,	50 *per cent.*
South Mountain,	80 *per cent.*

Without knowing the sources of the Quittapahilla springs, which may flow for a long distance among the cavernous limestone rocks, no estimate of the amount of water can be made by this means. The above percentages of rain fall upon the areas drained will be used in calculating the amount of water procurable from the sources under consideration.

The Union Canal Company have appropriated most of the water coming out of the gravel ridge north of the town, and have the following store reservoirs.

Clark's Dam,	*drainage area*		253	*acres.*
Stœver's	*do.*	*do.*	684	*do.*
Strock's	*do.*	*do.*	876	*do.*
			1813	*do.*

The North Lebanon Furnaces have appropriated the water from Forney's Dam, which drains 185 acres.

There is still a considerable area (formerly used by the Union Canal Company, but now abandoned by them,) at the head waters of the Brandywine Creek.

From these sources, if they were all collected, a supply could be procured. The areas drained by the four dams named is sufficient to furnish 3.000.000 gallons per day.

The objections to this plan are, that the entire surface is under cultivation, the expense of collecting would be considerable, the canal company and the furnaces would suffer some damages, and to have the water under sufficient head it would have to be pumped. For these considerations no further investigations in this direction have been made.

FROM THE LITTLE SWATARA CREEK.

This is a considerable stream, rising among the Blue Mountains in Berks county, and drains a large area of country, (102square miles.) Its minimum flow is probably 10,000,000 gallons per day, this, however, may be kept back in the Mill Dams above, but not for more than a day or two, at most, so that it will not be necessary to make arrangements for storing a large amount in a dam ; and if Steam is used, the Works can be located at any point on the stream. Surveys have, therefore, been made to the Horse Shoe Bend at Stœver's Mill, where the creek makes its nearest approach to the town. Steam power is recommended.

First. Because to insure a sufficient amount of water in dry seasons, when the greatest demands are made upon works, a very large impounding Reservoir would be necessary to store water for power.

Second. Water-power is of much greater value for the purposes of Flouring Mills, &c., where work can be diminished or entirely stopped in seasons of draught, without any considerable loss, than for pumping water for a town. At such times the demands are imperative and must be met.

Third. While the power at Stœver's Mill may be considered good for the purpose for which it is now used, it cannot, with safety, be depended upon for a water supply, and would have to be largely supplemented with Steam.

Fourth. The difficulties attending ice and freshets, and the risk of accidents to the dam and race ; which, although it may not be practically greater than with a Steam Engine and Boiler, yet the accidents in the former case are generally of a more serious character, and require a greater length of time to repair.

Fifth. If Water-power alone is depended upon, a much larger Store Reservoir will be necessary.

Sixth. By raising water from the creek by Steam, it will not be necessary to purchase a Mill-power, nor will there be any damage to the Mills below the pumping site, as the amount of water required for the town, will be but a small proportion of the average daily flow of the stream,—not more than three (3) per cent.

QUALITY OF WATER.

The character of the water of the Little Swatara Creek is satisfactory, subject, of course, to the objections to which the waters of all streams flowing through cultivated countries are liable, viz : Becoming turbid in times of freshet, and containing organic matter.

If a Reservoir of ample size and depth is constructed, pumping will not be necessary in times of freshet ; or, if required, subsidence will take place in the Reservoir.

The comparative hardness of the water, which indicates its value for culinary, washing, chemical and manufacturing purposes is 4.72 degrees, that is 37.78 grains of chemically pure soap are required to neutralize the salts in a gallon of water.

Table "B" exhibits the relative values of water taken for the various sources examined, and from streams supplying other cities.

The samples taken from the sources about Lebanon, were procured at an unfavorable season, as the streams were flowing full, and much surface water was combined with that form Springs. A greater degree of hardness would be shown by most of them in seasons of draught.

Table "B."

	Degrees of Hardness, "Clark's Test."	Grains of Soap required to neutralize Salts in one gallon of water.	Pounds of Soap consumed annually in neutralizing Salts, in 1,000,000 gallons of water per day.
Stœver's Dam, (at overflow,)	4.22	33.98	177.376
Little Swatara Creek, (at proposed pumping Station,)	4.72	37.78	197.212
Schnitz Creek, (at Horse Shoe pike,)	5.82	46.45	242.469
do. do., (at Zinn's Mill,)	17.03	136.24	711.173
do. do., (at proposed pumping Station,)	13.78	110.24	575.453
Hazeldyke, (at South Mountain,)	2.38	19.06	99.493
Hammer Creek, (Horst's Grist Mill Stream,)	2.12	16.98	88.636
do. do., (Horst's Saw Mill Stream,)	2.68	21.49	112.178
Beck Creek, (at Horse Shoe pike,)	15.12	120.98	631.516
Swift Creek, (do. do. do.,)	13.30	106.42	555.512
Quittapahilla Creek, (at junction of streams from two springs near Poor House,)	18.15	145.25	758.205
Schuylkill River, (at Philadelphia,)	6.5	52.08	271.857
Delaware River, (at Philadelphia,)	2.93	23.45	122.409
Susquehanna River, (at Harrisburg,)	3.91	31.25	163.125
Tulpehocken Creek, (near Reading,)	12.37	98.96	416.571

PUMPING BY STEAM FROM LITTLE SWATARA CREEK.

To raise three million gallons of water, per day, form this stream, to a sufficient elevation to pass the gravel ridge, will require it pumped two hundred and twenty (220) feet, which, with friction upon ascending main, will equal, two hundred and thirty (230) feet. This will give an available head at the Railroad and Eighth street, of one hundred and fifty (150) feet. To do this work, making all due allowance, will require an Engine of 160-horse power, working twenty hours.

A better, but more expensive arrangement, would be to have two Engines of 80-horse power each. If necessary one could be erected to start the Works, and the other when demanded; but it will no doubt be most economical to put both up together, as the saving in having them constructed at the same time, and the advantages of duplicate machinery in case of accident, will more than compensate for interest on the cost of the spare Engine, before it becomes necessary to meet the wants of the town.

ENGINES.

In selecting the kind of Pumping Engine best adapted for this work, the three most important considerations are, first-cost, durability and maintainance, (including attendance, fuel, oil, repairs, etc.)

So far as the practice of Engineers in this country is concerned, there is no form of Engine which is generally admitted to be the best; yet there is certainly a difference in their performance, and some are much superior to others.

From a careful investigation of the subject, and the experience gained by designing and supervising a number of different forms of Engines, I do not hesitate to recommend the Cornish Pumping Engine, as the one best adapted where any considerable amount of work is to be done, and which has thus far given the best and most satisfactory results. Some Patentees claim that their peculiar machines equal and even excel these Engines in efficiency, but as such claims are only made by those pecuniarily interested, and are neither sustained by a theoretical examination, or the practical working of their apparatuses, further consideration is unnecessary.

Table "C" shows the relative values of the three kinds of Pumping Engines, under which all the various forms may be classified.

Column "A" exhibits the number of pounds of water raised one foot high by the consumption of one pound of coal, or "duty."

Column "B," the amount of coal in pounds consumed, per day, raising 3,000,000 gallons of water 230 feet high.

Column "C," the cost of raising 3,000,000 gallons 230 feet high, including coal, attendance, repairs and all other expenses.

Table "C."

RELATIVE ECONOMY OF PUMPING ENGINES.

CLASS OF ENGINE.	"A."	"B."	"C."
High-pressure,	200,000	28.750	$171.12
Condensing,	350,000	16.428	104.94
Cornish,	550,000	10.454	69.06

The calculations are based upon the actual working of fair Engines, of each class, for the past five years, in the Philadelphia Water Works.

By careful management the cost of pumping at Lebanon can be much reduced as wages, coal and other expenses will be less. The above may be considered outside estimates.

It is poor policy to erect machinery of a temporary character to pump water, particularly when the amount to be raised is large and the elevation and distance great. The following estimates therefore contemplate engines of the most durable and efficient kind, but without unnecessary finish or ornament.

A pair of Bull Cornish Engines, say 48 inches diameter of steam cylinder and 18 inches diameter of pump plunger, length of stroke 8 feet, will cost	$30,000.
Boilers and all attachments	$10,000.
Engine House, foundations, stack and boiler walls	$15,000.
Total	$55,000.

(A Cornish Bull Engine is single acting and condensing, the steam cylinder is inverted and placed over the pump, the steam piston and pump plunger being directly connected. It is more simple and less expensive than an overhead beam Cornish engine and may be made as efficient.)

A pair of Condensing engines, with fly-wheels, steam cylinder 33 inches in diameter, double acting pump 15 inches in diameter, stroke of piston 4 feet, will cost	$23,000
Boilers and connections,	10,000
Engine house, foundations and stack, &c.,	15,000
Total,	$48,000

A pair of high-pressure engines, steam cylinder 28 inches in diameter, double acting pump 15 inches in diameter, stroke 4 feet, will cost,	$15,000
Boilers and connections	10,000
Engine house, foundations, stack, &c.,	15,000
Total,	$40,000

CONDUIT.

To convey the water from the Little Swatara Creek to town, it will first have to be raised 220 feet, through a forcing vain 5,000 feet long; it can then be carried by aqueduct 16,500 feet to a reservoir on the Southern slope of the gravel ridge.

From the reservoir to the centre of distribution at Eighth street and the Lebanon Valley Rail Road, a distance of 8600 feet, the water will be carried in a supply main.

The following estimates for this conduit will undoubtedly be somewhat modified when it is positively located, but they are sufficiently accurate to answer present purposes.

The ascending or forcing main to convey 3,000,000 gallons in 20 hours should be 20 inches in diameter; this will cost in place $30,000, taking iron pipe at 3 cents per pound, lead at 8 cents per pound, skilled labor at $2.50 per day, navvies $1.75 per day, and hauling pipe $5 per ton.

The aqueduct to be circular in form, 30 inches in diameter, constructed of arch brick laid in hydraulic cement; this would cost $42,900, taking the arch brick at $12 per thousand; cement and labor $6 per thousand, excavating, grading and filling 30 cents per yard, and where concrete foundations are necessary, $4 per pubic yard. This aqueduct would have to be covered by at least three feet of earth.

RESERVOIR.

A reservoir of sufficient capacity to allow the stoppage of the pumps for repairs, etc., and for a thorough subsidence when it is necessary to pump turbid water, should contain 10,000,000 gallons; if square the sides will be at the top of the embankment 290 feet long, and the water will be 21 feet deep. Its size and shape will of course be that best adapted to the location selected, and the estimates will be to a certain extent influenced thereby.

The sides will slope in the ratio of 1½ to 1; the earth to be well compacted, and that for the inner section selected, the banks to be 12 feet wide on top. The reservoir to be lined with clay-puddle two feet thick on the bottom, and from 12 to 18 inches thick on the sides. The puddle to be covered with sand at least four inches thick, and good hard bricks to be laid upon it, flat on the bottom and on edge on the sides, extending two feet above the water line. Suitable gate chambers and influent and effluent pipes to be provided, and the outer slopes to be covered with top soil and sown or sodded with grass.

Such a reservoir of the size above mentioned will cost, complete, $45,000.

In this estimate excavation and embankment is taken at 30 cents per yard, clay puddle $3 per yard, sand $2 per yard, and brick laid $14 per thousand.

DISTRIBUTING MAIN.

To allow the full capacity of the works to be employed, a 20 inch main will be necessary; this will cost laid in the ground (including crossing under the canal, stops, branches, etc.,) $52.000, materials and labor being taken as in the estimate for pumping main.

The entire cost of a works capable of pumping 3.000.000 gallons per day from the Little Swatara Creek, and delivering it at 8th street and the Lebanon Valley rail road, will be as follows :—

Engine house, Cornish Engines, &c.,	$55.000
Forcing Main,	30.000
Aqueduct,	42.900
Resevroir,	45.000
Distributing main,	52.500
Land and Damages, (say,)	10.000
	$235.400

Say, including Engineering and omissions, Two hundred and fifty thousand dollars, ($250.000.)

ANNUAL EXPENSE.

(All the estimates in this report of the cost of operating and maintaining the proposed works are based upon the actual cost at Philadelphia for the past five years, and will most probably be reduced in Lebanon.)

COST OF SUPPLYING 3,000,000 GALLONS PER DAY WITH CORNISH ENGINES.

Interest on first cost, at 7 per cent.,	$17,500
Maintainance,	25,200
	$42,700

WITH CONDENSING ENGINES.

Interest,	$16,800
Maintainance,	38,300
	$55,100

WITH HIGH-PRESSURE ENGINES.

Interest,	$16,100
Maintainance,	62,450
	$78,550

As the full capacity of the works will not be required for a number of years, the following estimates are made upon the annual expense of furnishing a supply from the proposed works of 1,000,000 gallons per day ; which amount will be sufficient to meet the demands of the town for several years after the completion of the works.

COST OF SUPPLYING 1,000,000 GALLONS PER DAY WITH CORNISH ENGINES.

Interest,	$17,500
Maintainance,	8,[illegible]00
	$25,900

WITH CONDENSING ENGINES.

Interest,	$16,800
Maintainance,	16,100
	$32,900

WITH HIGH-PRESSURE ENGINES.

Interest,	$16,100
Maintainance,	26,150
	$42,250

1,000,000 GALLON WORKS.

Should the expense of the work as above be considered as too great a burden for the present,′ a works capable of supplying one million gallons per day could be constructed, which would cost as follows:

PUMPING STATION.

A high pressure Engine with steam cylinder 22 inches in diameter, double acting pump 12 inches in diameter, (stroke of piston 4 feet,) and fly wheel—or a Duplex pump of same capacity,	$4,500
Boilers and connections,	2,500
Engine house, stack, &c.,	7,500
	$14,500
A condensing Engine with steam cylinder 31 inches in diamater, double acting pump 12 inches in diameter, (stroke of piston 4 feet,) and fly wheel—or a compound Duplex condensing Engine,	$8,000
Boilers and connections,	2,500
Engine house, stack, &c.,	7,500
	$18,000
A Bull Cornish Pumping Engine with steam cylinder 36 inches in diameter, pump plunger 16 inches in diameter, (stroke of piston 7 feet,) would cost,	$10,000
Boilers and connections,	2,500
Engine house, stack, &c.,	10,000
	$22,500

CONDUIT.

A forcing main 12 inches in diameter, will cost, laid in the ground,	$16,250
15 inch cement pipe in place of Aqueduct,	20,625
Distributing main 12 inches in diameter,	27,950
	$64,825

RESERVOIR.

A Reservoir of 3,000,000 gallons (say 160 feet square at water surface, water 20 feet deep,) constructed in the same manner as the 10,000,000 gal. Reservoir, as described will cost,	$18,500

The works will therefore cost by using a High-pressure Engine—

Engine, Engine house, &c.,	$14,500	
Conduit,	64,825	
Reservoir,	18,500	
Land Damages, (say,)	5,000	
		$102,825
Say, including Engineering, Omissions, &c.,		115,000
With Condensing Engine, (say,)		120,000
With Cornish Engine, (say,)		130,000

THE ANNUAL EXPENSE

Of supplying 1,000,000 gallons per day with these works will be, by using a Cornish Engine—

Interest on Cost of Works,	$9,100
Maintainance,	8,400
	$17,500

With a Condensing Engine—

Interest on Cost of Works,	$ 8,400
Maintainance,	12,770
	$21,170

With a High-pressure Engine—

Interest on Cost of Works,	$8,050
Maintainance,	20,900
	$28,950

FROM THE SCHNITZ CREEK.

Schnitz Creek has its rise in the South Mountain, and is made up of several streams, (the principal one being Furnace Creek,) which have their confluence in the vicinity of Cornwall. A considerable tributary joins with the creek at Zinn's Mill from the Southwest. The stream then flows in nearly a Northern direction to within about two miles of the town, when it bends to the west, keeping about the same distance off, and empties into the Quittapahilla Creek. The area drained by Schnitz Creek above the point where it approaches nearest the town, is 28,960 acres, or 11.25 square miles. The upper waters are among the mountains, which will probably always be kept in forests, but below Cornwall most of the country drained is under cultivation.

This source has already been presented as a proper one from which to obtain a supply of water; the project is to erect Steam Pumping Machinery on the Creek, at the point where it approaches nearest the town, to force the water into a Reservoir placed upon the first hill below the town west of the Cornwall road.

From this point the water will be carried by a distributing main, to the Court House.

QUALITY OF WATER.

This is satisfactory as far as hardness is concerned, it being but 13.78 degrees.

Above Cornwall no possible objections can be raised to the character of the water, nor is there the least probability that it will even be contaminated, as the mountain sides are only valuable for the growth of timber. In regard to the influence of the extensive mining operations at Cornwall, there are differences of opinion, both as regards the present effects, and what they may be in future. As for the presence of iron in the water no apprehensions need be felt, for with proper arrangements, most of it can be gotten rid of by subsidence, before the water reaches the proposed Pumping site. How far the copper or sulphur, found in such quantities with the iron ore does, or will affect the potability of the water, is the question most difficult of solution, and I know of no positive means of arriving at it. A careful analysis would give the precise amount and condition of the mineral matter in solution only of the specimen examined. The amount of copper and sulphur, vary with the working of the mines and the amount of rain, or other agents, which disintegrate and wash them into the stream.

The mining evaporations at the head waters of the Schuylkill, affect the river so that at Philadelphia, 100 miles from the mines, there was in 1862, 1,508 grains of Sulphuric acid to the gallon, which amount has been increasing each year, as the mines have been more thoroughly developed. At the same time there werr, at Reading, 2,652 grains of Sulphuric acid to the gallon. From this point up the river no fish are found when at its ordinary stages, and the water is unfit for use, even in Steam boilers.

No other objection exists to the Schnitz Creek as a source of supply. The amount of Organic matter drained from the cultivated country, need not affect the salubrity of the water to such an extent as to make it objectionable, as arrangements can be made to prevent any barn-yard or road washings, from finding their way directly into the stream.

QUANTITY OF WATER.

Upon this subject there need be no apprehension, for by getting control of Zinn's Mill, or constructing a Store Reservoir, of sufficient capacity, the amount required (3,000,000) per day, can be obtained at all times.

Should the danger of contamination from the washings of the Cornwall Ore Banks, not be considered of sufficient importance to prevent the use of this source for a supply. The cost of the work can be determined from the following approximate estimates.

Suitable arrangements should be made for conveying all barn-yard and road drainage upon the road, and so distributing it that none can flow into the stream without passing for some distance over grass or cultivated soil ; this will not only prevent the contamination of the water, but will also add to the fructility of the soil, by giving to vegetation that which now is wasted. Catch Dams will be necessary to collect the sand which would otherwise injure and clog the Pumping machinery. By straightening the creek, removing all obstructions in the channel, rip-rapping the sides, and if possible having a strip, say 10 feet wide, on each side of the creek, constantly kept in grass ; little if any objectionable matter can find its way into the stream. These arrangements should extend from Zinn's Mill to the Pumping Station.

If the control of Zinn's Mill Dam can be secured at a reasonable price, it would be of great advantage for furnishing water in times of draught, as it is required for the town. All the shallow and swampy parts of the dam should be deepened, so as to make the storage capacity as great as possible, and to prevent the growth of Aquatic plants, and development of confervæ and animalculæ.

ENGINES.

Table "D" represents the comparative value of the three principal classes of Engines, for raising 3,000,000 gallons 100 feet high.

Table "D."

CLASS OF ENGINE.	"Duty" in foot pounds.	Daily consumption of Coal in ℔s.	Daily running Expenses.
High pressure,	200,000	12,500	$74.40
Condensing,	350,000	7,145	45.63
Cornish,	550,000	4,545	29.16

The same remarks are applicable to Table "D" as to Table "C."

To pump 8.000.000 gallons, 100 feet high, in twenty hours, will require—

A pair of Bull Cornish Engines, steam cylinders 36 inches in diameter, pump plunger 18 inches in diameter, stroke 8 feet,—

Will cost put up,	$25.000
Boilers, connections, &c.,	5.000
Engine house, foundation and stack,	12.500
	$42.500

Or a pair of Condensing Engines, with fly wheels, steam-cylinder 24 inches in diameter, double acting pump 15 inches in diameter, length of stroke 4 feet,—

Will cost,	$20.000
Boilers, connections, &c.,	5.000
Engine house, foundation and stack,	12.000
	$37.000

Or a pair of High-pressure Engines, with fly wheels, steam cylinders 20 inches in diameter, double acting pumps 15 inches in diameter, Length of stroke of piston, 4 feet,—

Will Cost, put up,	$10.000
Boilers, Connections, &c.,	5.000
Engine House, foundation and stack,	10.000
	$25.000

WELL at Engine house, and arrangements for protecting the purity of the water, $10.000

FORCING MAIN.

To connect the Engines with the reservoir, will require a forcing main 20 inches in diameter, and 4100 feet long, which will cost, laid in the ground, $25.000

RESERVOIR.

A reservoir of 10.000.000 gallons may cost more erected on the site selected for it than that proposed on the Gravel Ridge, owing to fissures in the underlying limestone rock;—$3.000 will therefore be added for securing the bottom, making the cost of the reservoir, $48.000

DISTRIBUTING MAIN.

From the reservoir to the Court House, a distributing main, 6.500 feet long and 20 inches in diameter, will cost, laid in the ground, $39.000.

The entire cost of raising 3.000.000 gallons per day from Schnitz Creek, and delivering it at the Court House, will be,—

Engine House, Cornish Engines, &c.,	$42.500
Well and protective arrangements,	10.000
Forcing and Distributing Mains,	64.000
Reservoir,	48.000
Land Damages, say,	5.000
	$169.500
Say, including all expenses,	$190.000

ANNUAL EXPENSE.

Of furnishing 3.000.000 gallons per day, with Cornish Engines—

Interest on Cost of Works,	$13.300
Maintainance,	10.650
	$23.950

With Condensing Engines—

Interest on Cost of Works,	12.950
Maintainance,	16.600
	$29.550

With High pressure Engines—

Interest on Cost of Works,	12.110
Maintainance,	27.160
	$39.270

To pump 1.000.000 gallons per day by the above works, will cost with Cornish Engines—

Interest on Cost of Works,	$13.300
Maintainance,	3.400
	$16.700

With Condensing Engines—

Interest on Cost of Works,	12.950
Maintainance,	5.600
	$18.550

With High pressure Engines—

Interest on Cost of Works,	$12.110
Maintainance,	9.100
	$21.210

The above estimates contemplate a works of the capacity you directed, and of the most complete and durable construction.

The following estimates are for a works capable of supplying 1.000.000 gallons per day; and will enable you to compare this with other sources of supply, and judge of the relative merits; and should you deem it advisable to adopt the small works, the information will be valuable.

1.000.000 GALLON WORKS.

A high pressure pumping engine, with fly wheel, steam cylinder 18 inches in diameter, double acting pump 12 inches in diameter, length of stroke 4 feet; or "duplex pump" of same capacity, will cost	$4.000
Boilers and Connections,	1.500
Engine House, stack, &c.,	6.000
	$11.500

A condensing engine with fly wheel, steam cylinder 22 inches in diameter, double acting pump 12 inches in diameter, length of stroke 4 feet, or a compound "duplex" condensing Engine, will cost,	$7.000
Boilers and Connections,	1.500
Engine house, stack, &c.,	7.500
	$16.000

A Cornish Engine is not estimated for, as the work to be done would not warrant the expenditure, and in small engines the duty falls off rapidly, and they cannot be made to operate more economically than good condensing engines, with fly wheels.

With these works, a 3.000.000 gallon reservoir is estimated as above, and $1.500 added to secure the bottom, making it cost $20.000.

The forcing and distributing mains, 12 inches in diameter, will cost, $31,500

The total cost of such a works will be—

Engine, Engine House, &c.,	$11,500
Well and protecting water,	7,500
Reservoir,	20,000
Forcing and Distributing Mains,	31,500
Land Damage, say,	5,000
	$75,500

Say, including all expenses, by using a high-pressure engine, $84,000, or by using a condensing engine, $89,000

The Annual cost of furnishing 1,000,000 gallons by these works will be—

By High-pressure Engine—

Interest on cost of works,	$5,880
Maintainance,	9,100
	$14,980

With Condensing Engine—

Interest on cost of works,	$6,230
Maintainance,	5,600
	$11,830

FROM THE SOUTH MOUNTAIN.

This project is not new, but has been presented to you, and its merits to a considerable extent discussed.

That portion of the South Mountain, lying between Cornwall and the Hammer Creek Gap, has been examined and surveyed.

The available sources are the Hazeldyke and West branch of the Hammer Creek, and are sufficiently elevated to flow into the town by gravitation. The areas drained by them, above the proposed point from which to obtain a supply, are entirely upon the mountains, and probably always will be covered with forests. The Catchment basins are well adapted for collecting the water and maintaining it in the most desirable condition; which is remarkably pure and free from mineralization.—The hardness of the waters (see Table "B,") is less than 2.5 degress, and for all purposes, is in every respect desirable. The stored water in the Reservoirs will be softer at it will be principally rain water.

QUANTITY OF WATER.

These sources connot be relied upon to furnish 3,000,000 gallons per day, at all seasons of the year, yet taking the excellent quality of the water into consideration, and as the demand for 3,000,000 gallons is prospective, it has been deemed advisable to present this source for your examination.

The total area drained by the Hazeldyke is 0.425 miles, or 272 acres, and that of the West Branch of the Hammer Creek 1.312 miles, or 839.7 acres. The combined areas are 1.737 square miles, or 1111.7 acres.

Table "E" represents the amount of water which may be collected from these areas per day, during the driest month, season and year, and during an average day, month, and season or year. 80 per cent. of the precipitation is considered as available. These observations extend over 40 years.

Table "E."

	Rain-fall in Inches.	Date.	Daily average flow in gals. from Areas drained.
Driest Month in 490 months,	0.22	Dec1828	211,300
do. Spring in 40 seasons,	5.82	1845	1,902,000
do. Summer in 40 do.,	5.86	1849	1,923,000
do. Autumn in 41 do.,	5.99	1856	1,992,000
do. Winter in 40 do.,	6.01	1829–30 1857–58	2,022,000
do. Years in 40 years,	30.86	1840	2,536,000
Daily average of 14,915 days,	0.1148		3,465,000
Monthly do. 490 months,	3.494		3,442,000
Spring do. 40 seasons,	10.96		3,662,000
Summer do. 40 do.,	11.71		3,864,000
Autumn do. 41 do.,	10.11		3,351,000
Winter do. 40 do.,	8.94		2,998,500
Yearly do. 40 years,	42.126		3,471,500

In the month of December, 1828, the amount collected from the surface would only have been 211.300 gallons, per day, during that time the springs would have flowed about 200,000 gallons, making the entire available supply 411.300 gallons. During the driest recorded season a daily average flow of 1,902,000 gallons could be collected from the surface ; and the daily flow during the season of lowest average (winter) was 2,988,500 gallons. It will, therefore, only be necessary to construct Store Reservoirs of sufficient capacity, to impound the excess of water, so as to make up for deficiencies during seasons of draught.

Some loss by evaporation from the surface of the water stored, will of necessity occur careful observations made by the Croton Aqueduct Board of New York, show an average evaporation from the surface of their Store Reservoirs, of 24 inches per annum. This is of course greatly influenced by the location and exposure to sun and wind, the amount would probably be less in the Reservoirs proposed at the South Mountain. Allowances for leakage and soakage must be made. depending to a great extent, upon the manner in which the Reservoirs are constructed. Taking all probable losses into consideration a daily supply of 1,500,000 can be safely estimated upon.

DAMAGES.

It would probably be advantageous to purchase the Horst's Mill property at once, if procurable at a reasonable expense, as the views of actual damages would be largely in excess of the real amount. By constructing Store Reservoirs of ample capacity, the storm water, which under ordinary circumstances is wasted, would be utilized (a portion of it being sufficient to meet the wants of the town,) and for some years the water powers upon the stream, would be rendered more valuable on account of a more constant flow.

STORE-RESERVOIRS.

At least two Reservoirs should be constructed, one to store the water from the Hazeldyke drainage area, and the other that from the Hammer Creek drainage area.

A number of eligible sites can be found where Reservoirs of large capacity can be made at moderate cost, by constructing dams across the Valleys ; and it would be true economy to build them of ample dimensions at first.

To make up for the deficiencies of the least precipitation, (December, 1828,) will require a storage capacity of 40,000,000 gall's., this would be filled in 20 days, by the surplus of the average monthly rain fall, or by taking the months previous and subsequent to this, (November, 1828, and January, 1829,) it would be filled in less than 14 days.

To insure against all contingencies, a Reservoir of 35,000,000 gallons capacity is recommended on Hammer Creek, and one of 15,000,000 gallon capacity on the Hazeldyke. Without actually locating them, and making detailed plans, precise estimates cannot be furnished ; but the following will be sufficient for the purposes of this report, and are based upon the actual cost of such a Reservoir, constructed for the water supply of the City of Reading, Penna., upon a similar site to those proposed.

Hammer Creek Reservoir,	$22,000
Hazeldyke Reservoir,	16,000
Intercepting Drains,	2,000
	$40,000

These Reservoirs to be constructed by making an embankment of earth and stone, with a puddle wall placed in it. The overfall to be of masonry, and the inside and outside of the embankment sloped 2 to 1, and pitched with stone. The stumps of trees, and top soil to be removed from the area to be covered with water, and the slope of the sides made at least 2 to 1 to deep water. The edges to be defined by filling up any land which will be swampy when the Reservoirs are full, and suitable drains, effluent pipes and gates to be provided.

Cheaper structures can be erected, but no work of a temporary character should form a part of the water supply of a town, for the damages incident to the failure of a dam, might be many times its first cost ; besides the difficulties and annoyances occasioned by the temporary stoppage of a supply of water to the town.

A portion of the water of the Hazeldyke is diverted and carried some distance west of the course of the stream, for the use of several farms, and the water of the Creek is also used upon the farms through which it flows, before it sinks and disappears.

It would, therefore, be necessary to furnish a supply to these by other means.

CONDUIT.

The waters from the store reservoirs can be brought together by means of terra-cota or cement pipes, and then conveyed by an aqueduct, 20 inches in diameter, and 20,000 feet long, to a suitable site for a reservoir, 120 feet above Eighth street and the Rail Road, and from thence carried by means of a cast iron distributing main, 16 inches in diameter, and 14,500 feet long, to the Court House.

A 3,000,000 gallon reservoir will be ample for these works, and will cost about as much as that proposed for the Schnitz Creek project.

THE EXPENSE OF THESE WORKS WILL BE—

Store Reservoirs,	$40,000
Aqueduct and branches,	42,000
Reservoir,	20,000
Distributing Main,	72,500
Land and Damages, (say,)	20,000
	$194,500
Say, including Engineering, Omissions, &c.,	$220,000

The Annual Expense of furnishing an average of 1,500,000 gallons per day, will be—

Interest on cost of works,	$15,400
Watchman at reservoirs,	200
Repairs and renewals,	2,000
	$17,600

The entire works, as above described, need not be immediately constructed, and some modification of parts may be made which will cheapen the work, and will not seriously affect its permanency, or, ultimate efficiency. While an Engineer should not recommend any but the most durable and adequate arrangements, a proper regard for the first cost, and the amount of money which may be prudent or desirable to invest in an enterprise, may warrant a departure from this rule.

The following modifications of the above plan will meet the requirements of your town for the present, and will necessitate but little alterations and loss when enlargement is required.

To construct a dam, with a storage capacity of 20,000,000 gallons, upon the fork of the Hammer Creek supplying Horst's Grist Mill, so located that the water from the other branches may be led into it. The water to be conveyed from this dam by a cement pipe, 20 inches in diameter, to a suitable site for a reservoir of 1,000,000 gallons capacity, (so located that another reservoir may be placed alongside of it,) and carried from thence by a 12 inch iron pipe to the centre of the distribution.

These works would cost built in the cheapest possible manner, with a due regard for the important purposes for which they are constructed—

Store Reservoir,	$20,000
Distributing Reservoir,	9,500
Cement Conduit,	32,000
Land and Damages,	10,000
Distributing Main,	43,500
	$115,000
Say, including all expenses,	$130,000

The 12 inch distributing main cannot be depended upon for more than 1,000,000 gallons per day, and this can only be done at a considerable loss of head.

The cost of furnishing 1,000,000 gallons of water per day by these works will be—

Interest on cost,	$9,100
Watchman,	200
Repairs, renewals, &c.,	1,500
	$10,800

FROM THE QUITTAPAHILLA CREEK.

The sources of the Quittapahilla Creek are within two and a half miles of the Court House, and consist of two large springs issuing from the limestone rocks, 360 feet apart. The Creek flows through cultivated fields, crossing the turnpike near the Borough line, where several additional springs empty into it. At this point there is a dam originally built for a mill power, and now owned by the Union Canal Company, upon which they have erected a steam pump to force water into the summit level of the canal.

The purchase of the dam, and the long continued use of the water for canal purposes, may legalize, or justify, its diversion from its natural course.

Should the use of Quittapahilla for a water supply be deemed inadvisable, it would be to the advantage of the town to purchase it, as a matter of sanitary importance. For the canal requires the diversion of most of the water at a time when it is most essential to that portion of the town through which it flows; and when the stream furnishes the least water.

The Creek is the only sewer by which the town drainage is carried off, and a full supply of water to dilute and transport such objectionable matter becomes a positive necessity, to the health and comfort of the citizens.

Control of this dam should be secured ; the other dams in the town removed, and the creek confined to a well defined bed.

The reliable quantity of water procurable from this stream is difficult to estimate, as the source of the springs, (which furnish the greater part of the water,) can only be conjectured. There would, however, be no difficulty in procuring a supply of 2,000,000 gallons per day at all seasons of the year.

To secure this amount it will be necessary to convert the dam, now owned and used by the Canal Company, into a store reservoir, by excavating the accumulated mud, and defining the shore line by making a steep descent into deep water. A by-wash for conveying storm water past the dam will also have to be constructed.

QUALITY.

The quality of the water is good ; there is some objectionable drainage into it, between the springs and the dam ; and to protect it thoroughly, it will be well to divert the stream in a new channel, and allow the storm water to flow in the old water-course, so as to convey all impurities below the store reservoir.

This water is harder than that from any of the other sources ; but it can be readily used for washing. Its hardness, as exhibited by the specimen tested, is 18.15 Degreees. See Table "B."

Pumping engines could be erected at the dam, and the water immediately furnished to the town, without a reservoir. This would necessitate the duplicating of the pumping machinery, which however is desirable for other reasons,and the erection of a stand-pipe, an essential appendage allowing the engines to be worked without risk at a greater speed, and giving a steady flow through the mains in the town. There are works now being constructed by which the water is forced directly into the distributing mains without either stand-pipe or reservoir. Such works are sometimes less expensive in first cost, but are not so in reality, and the saving if any is made at the loss of one or both of these important parts of a complete system of water works.

The stand-pipe to be 5 feet in diameter, and 120 feet high, made of boiler plate, with cast iron base provided with proper inlet and outlet pipes. The pipe to be surrounded with brick work for a height of 50 ft.

These works will cost, by using a pair of high-pressure engines, each capable of raising 1,000,000 gallons per day constructed as described for Schnitz Creek :

Engines,	$9,000
Boilers and Connections,	2,000
Engine House, Stack, &c.,	7,500
Stand-pipe,	8,000
Purchasing and cleaning out Dam, Constructing Drains, By-wash, &c.,	35,000
12-inch Main, (say)	24,000
	$85,500
Say, including all expenses,	$100,000

The Annual cost of furnishing 1,000,000 gallons per day by these works will be—

Interest on Cost,	$7,000,
Maintenance,	9,000,
	$16,000

DISTRIBUTION.

The distribution has not been included in any of the above estimates, as the cost with any of the projects will be about the same. The following estimates are for a distribution with a capacity of but 1,000,000 gallons per day, so arranged that it may be increased, as the wants of town demand, with but little loss, by laying additional feeders on streets not now occupied, or by taking up some of the smaller pipe and substituting larger. The estimates are for cast iron mains, with the requisite number of street slops and 50 fire hydrants.

Some towns are now laid with a patent water pipe, made of sheet iron riveted together, lined and covered with hydraulic cement.—Several Companies are engaged in its manufacture, and furnish it about 20 per cent. cheaper than cast iron mains. I have given the subject some attention, but thus far have felt unwilling to recommend its use, particularly for town distribution, where there are so many disturbing elements endangering its permanency.

Cast iron mains have been in use in Philadelphia for over 40 years, and so far as examined are little the worse for their use, and for the purpose of carrying water, are as valuable as when first put into the ground. After the iron rust has accumulated to certain thickness upon the inside and outside of the pipe, it forms a perfect protection and arrests all further action.

The inducement of a slight saving in expense, is not sufficient to warrant the substitution of an uncertainty, for what is known to answer the purpose permanently and satisfactorily.

I would, therefore, recommend the laying of cast iron pipes, jointed with lead in the usual manner.

The stop-cocks and fire hydrants recommended, are similar to those which I designed for the City of Philadelphia, and which are in u there and in many other places. There are no patents upon them, and they can, therefore, be made by any competent machinist.

The following distribution will be adequate for the present. The pipes to be laid on

Walnut street, from Sixth street to Ninth street.
Chestnut street, from Fourth street to Tenth street.
Cumberland street, from Third street to Quittapahilla Creek.
Willow street, from Seventh street to Tenth street.
Weidman street, from Fifth street to Seventh street.
Lehman street, from Fourth street to Tenth street.
Guilford street, from Eighth street to Tenth street.
Fourth street, from Cumberland street to Walnut street.
Fifth street, from Willow street to Chestnut street, and 500 feet north of Weidman street.
Sixth street, from Willow street to Walnut street.
Seventh street, from Cumberland street to Willow street, and from Weimer street to Lehman street.
Eighth street, from Walnut street to Guilfork street.
Ninth street, from Locust street to Guilford street.
Tenth street, from Strawberry alley to the Lebanon Valley Railroad, and from the Ole Borough Line to Guilford street.

This distribution will probably require considerable modification, but not such as will materially affect its cost. It will require, say, 4,000 feet of 8 inch pipe, 13,500 feet of 6 inch pipe, and 13,000 feet of 4 inch pipe. This is exclusive of the pipe from the proposed Reservoir to the centre of distribution. Nearly 6 miles of distributing main. Also, 40 street stops, 50 fire hydrants, and the requisite branches and special castings. This will cost, say, $45,000 laid and connected ready for use.

Table "F" exhibits the comparative capacity, cost and annual expenses of the various projects considered. It shows the annual expense of furnishing a supply of 1,000,000 gallons per day.

Table "F."

COMPARATIVE COST OF WORKS.

PROJECT.	Daily capacity in Gallons.	Cost of Works.	Annual expense of furnishing 1,000,000 gallons per day.
Little Swatara Creek,	3,000,000	$250,000	$25,900
do. do. do.,	1,000,000	130,000	17,500
Schnitz Creek,	3,000,000	190,000	16,700
do. do.,	1,000,000	89,000	11,830
South Mountain,	1,500,000	220,000	17,600
do. do.,	1,000,000	130,000	10,800
Quittapahilla Creek,	1,000,000	100,000	16,000

RECOMMENDATION.

After a careful consideration of the varous projects for procuring a water supply for Lebanon, the SOUTH MOUNTAIN GRAVITATION SCHEME appears the most desirable.

The quantity procurable from this source will not reach the amount you suggested, but for the present wants of the town, and until the population is between 25,000 and 30,000, it is amply sufficient. When the town grows larger the water from Beck and Swift Creeks can be brought into, or one of the other projects may be used, supplementary to the South Mountain supply.

The principal reason for recommending this plan, is the desirable quality of the water, no better being furnished to any city. It is *pure* and *soft*. The value of soft water for culinary, mechanical, or chemical purposes is allowed by all, and its superior potability generally admitted.

Table "B" exhibits the relative value of water for the purposes in which soap or alkali is used. The precise amount required in your town is difficult to estimate, but it is probably above 5 per cent. of the daily supply; assuming, therefore, that with a supply of 1,000,000 gallons per day, 50,000 gallons are used with soap, which costs an average of 6 cts. per pound, there is an *annual saving* in using the water from the South Mountain, in place of the water from the Little Swatara Creek, of $291. In using the water from the South Mountain in place of that from Schnitz Creek, of $1425, and in using the water from the South Mountain in place of that from the Quittapahilla Creek, of $1974.

To this should be added a saving in teas, coffees, and other materials from which decoctions are made; and the trouble and expense obviated by the use of soft water, which forms no scale in steam boilers. The water from the South Mountain can be brought into and distributed through town, with an average available head of 100 feet by the 1,000,000 gallon works, described above, at a cost of less than $200,000.

A small price to pay for the benefits and advantages of an abundant supply, of such unexceptionable water, procurable at all hours in any part of the dwellings or factories.

REVENUE.

In considering a water supply the probable Revenue, which it will yield, becomes a question of importance, not so directly, however, as if the investment is made by a company looking merely to a pecuniary return.

Many of the advantages (such as the sanitary effects,) of a copious supply of wholesome water, can have no money value placed upon them, and others, such as the protection against fire, flushing of gutters, and the stimulation of manufactories, are so diffuse in their benefits as to be compensated for only by assessments levied on the entire community.

The money invested in a water supply, if judiciously expended, is fully represented by the enhanced value of all the property reached by its influences. Yet the interest upon the bonds issued for the construction of such work, and the expense of maintaining and operating them must be met, and the ultimate liquidation of the loan provided for. The question of how this can be done, in the least burdensome, and most equitable manner, becomes one of importance. The same rate or mode of taxation has seldom been adopted by any two places; some have secured a large proportion of the amount by general taxation, made in the early history of the Works, before their use by private parties becomes common. Others make the principal assessment upon those who directly use the water. Each place deciding this matter according to the prevailing judgment of right and expediency.

The practice adopted by some cities, of charging the property in front of which the distributing pipes are laid, a sufficient price to pay for the expence of purchasing and laying it, appears to be an equitable one.

It taxes the property directly benefited; and reduces the first cost of the works materially, making their construction possible, where in some cases the undertaking would involve expenditures, which, if paid for out of loans might injuriously affect their value, and thus increase the cost of the works unnecessarily or prevent their construction.

A very moderate charge for water to direct consumers is 1½ cents per 100 gallons, or $150 per million gallons.

When the average of 1,000,000 gallons per day is furnished; allowing one-third of it for municipal uses and losses of all kinds, the works will yield an income of $36,500 per annum, an amount greater than the cost of furnishing 1,000,000 gallons by any of the plans proposed, and these rates are very low, some towns charging double this price.

(Boston charges 3 cents per 100 gallons by measure for water supplied.)

Maintaining the works will most probably be burdensome for the first year or two, but before five years they will no doubt become self-sustaining, and before 20 years' bonds mature, they will have paid for themselves entirely. At least this is the history of water works generally where care and prudence are exercised in their construction and management.

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